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ABSTRACT

Results are reported of an investigation of the relationship between preservice teachers' cognitive developmental level and their ability to teach effectively during student teaching. Other variables, including teacher locus of control, SAT verbal and math scores, and teaching effectiveness, were also examined. Elementary (N=22), middle school (N=31), and high school (N=24) preservice teachers were individually tested with four Piagetian tasks, and were tested for external or internal locus of control. Student teaching abilities were assessed using the Teacher Performance Assessment Instruments (TPAI). Included among the results was the lack of a significant relationship between any of the broad teaching performance categories and teacher cognitive development. Percentages are also reported and discussed for cognitive developmental levels of the elementary, middle school, and high school preservice teachers. (CS)

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# THE RELATIONSHIP AMONG FORMAL OPERATIONAL ABILITIES, SELECTED ACHIEVEMENT VARIABLES AND STUDENT TEACHING SUCCESS

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# THE RELATIONSHIP AMONG FORMAL OPERATIONAL ABILITIES, SELECTED ACHIEVEMENT VARIABLES AND STUDENT TEACHING SUCCESS

Success in teaching requires a person to master many complex sets of behaviors that researchers are only today beginning to list and comprehend. Effective teaching demands an individual who can understand and appropriately deal with classroom management and behavior control. It demands complicated curriculum writing skills (e.g., writing objectives, lesson and unit plans, sequencing learning activities). It requires a knowledge of and an ability to apply principles of learning theory (e.g., cognitive development, models of learning, learner needs). It demands an ability to actualize a variety of teaching strategies (e.g., activity, discussion, lecture and questioning techniques).

These complex teaching behaviors and the thought processes underlying them appear to be quite similar to those described by Inhelder and Piaget (1958) and broadly called formal operational abilities. As Sunal and Sunal (1980) state, "Piaget suggests that formal behaviors in teaching information to children involve isolating important factors, considering all possibilities, generating alternative hypotheses, conducting systematic investigations, and establishing possible solutions." However, little effort has been made to ascertain whether a teacher's success is influenced by his own cognitive development. The purpose of this paper is to investigate the relationship between preservice teacher's cognitive developmental level and their ability to teach effectively during student teaching. In addition, the relationship between several other variables, including teacher locus of control and SAT verbal and math scores, and teaching effectiveness will also be probed.

## RELATED RESEARCH

Inhelder and Piaget (1958) described four subcategories of thought bridging the transition from early concrete to fully formal thought. These subcategories are designated as stage IIa, early concrete operational; IIb, concrete operational; IIIa, early formal or transitional, and IIIb, late or fully formal. As an individual progresses through these stages, he become increasingly more able to deal with tentative and hypothetical propositions. Operationally defined, formal operations is an individual's ability to identify and control variables, to use proportional logic, to apply probabilistic logic, to use correlational thinking and to use combinatorial reasoning abilities.

Logically, one can draw a strong parallel between the types of decisions teachers must make in a classroom and those involved in solving Piagetian formal operational problems. Many classroom variables are involved in sensing learner difficulties, hypothesizing about various causes, prescribing specific remediation and testing for new difficulties. Minimally, a teacher engaged in such behavior might be showing abilities in identifying and controlling variables. Combinatorial reasoning abilities might also be necessary if a teacher tried to list all possible causes for a learning difficulty or all possible remedial tasks before selecting the appropriate one. Correlational and probabilistic reasoning might also be important in noting which sets of teacher behaviors correspond to desired student behaviors. Yet despite this logical connection, mixed results have been reported by studies investigating a potential relationship between formal operational abilities and the act of teaching.

Sunal and Sunal (1980) compared elementary and middle school preservice teachers of differing cognitive development levels on their performance in teaching a short content unit. For the study the authors used a self constructed checklist that rated students planning and instructional behaviors. They found a .48 correlation ($p<.01$) between their pencil and paper formal operations test and teaching behavior.

Miller (1980) trained elementary, middle and secondary preservice teachers to deal with the complex nature of the science activity. She then collected data on subjects abilities to teach an activity lesson to peers in microteaching and to the appropriate level public school students. She later correlated subjects activity teaching scores with their cognitive developmental level and found no significant relationship between the two variables. Miller only collected data on one microteaching and one regular teaching lesson for each subject, however. Perhaps with a measure of teaching ability reflecting a longer evaluation period, these results might differ.

Ehindero (1978) investigated concrete and formal elementary teachers' abilities to plan a hypothetical teaching program and to actualize their teaching intentions in practical classroom situations. He found a significant relationship between cognitive developmental level and teachers' abilities "to identify and provide relevant instructional materials" to students.

Numerous authors have simply studied the developmental level of preservice teachers and most have found that formal thinking abilities are not necessarily the status quo. For example, Lawson, Nordland and Devito (1975) found 18% concrete, 66% transitional and 16% formal among a group of

preservice elementary teachers. Juraschek (1974) found 52% concrete and 48% transitional or formal operational in a similar group of elementary preservice teachers. A secondary purpose of this study will be to partially replicate these studies and to compare the developmental level of elementary, middle and secondary preservice teachers.

## Subjects

Seventy-seven preservice teachers who were preparing to be either elementary generalists (grades K-4) (n=22), or middle school (grades 4-8) (n=31) and high school (grades 7-12) (n=24) science specialists were the subjects in this study. All were in their senior year and data were collected within two quarters of student teaching. The elementary teachers were volunteers from among a large pool of students at that level. In no way did they appear to be different from those who did not volunteer. The middle and high school teachers completed the tasks as part of their regular course requirements.

## Procedure and Instruments

Each subject was individually tested with four Piagetian tasks during the quarter they took science methods. The tasks are outlined in Figure 1. In addition, each completed the James (1957) locus of control instrument by rating a set of 60 statements from strongly agree to strongly disagree. For example, one item states, "A great deal that happens to me is probably just a matter of chance." A high score, indicating the person strongly agrees with these statements designates an individual whose actions are largely controlled by his environment. These persons are called externals because they do not feel that control their own destiny. A low score

indicates an internally controlled person who feels his plans and actions to a large extent determine his future and success.

In student teaching, all students were required to prepare and teach a two week unit to public school students. During the unit they were assessed by their university supervisor and sponsor teacher using the Teacher Performance Assessment Instruments (TPAI) (Capie, Anderson, Johnson and Ellett, 1979). This instrument was created to assess beginning teacher competence in four broad areas--teacher planning, classroom procedures, interpersonal skills and professional standards. In each of these areas several general teaching competencies are measured by various specific rating items, called indicators. Figure 3 lists one competency within the classroom procedures component as well as one indicator which reflects some part of that competency. Four more indicators would be rated and used as evidence of having attained this specific competency. An important part of the Likert type scale used for all indicators is that each point of the scale is precisely described. To get a score of three on indicator 4, a student must show the specific behavior listed opposite that number. This rating system thus minimizes bias from different raters and allows the comparison of one teacher to the next. All 16 competencies within the four broad areas are listed in Figure 3.

Several other measures were available on most of the subjects and thus were included in the analysis. These include SAT math and verbal scores, grade in the science methods class, overall grade point average and the NTE common score.

Data Analysis

Piaget tasks were scored using a point system developed by Lawson, Nordland and DeVito (1975). Responses for a task which were early concrete operational in nature (level IIa) were given 1 point, those at a concrete operational level (IIb) were given 2 points, responses at a transition to formal operations level (IIIa) were given 3 points and fully formal responses (IIIb) were given 4 points. On the four tasks a top score of 15 points was possible. The conservation of displaced volume, if correctly solved was worth only 3 points, since this indicated only level IIIa thinking. All others demanded level IIIb thinking and thus were worth 4 points.

A decision rule was employed whereby locus of control scores were divided into three groups. Subjects whose scores fell more than one half of a standard deviation below the mean were considered internals; subjects whose scores fell more than one half a standard deviation above the mean were considered externals. Those falling in the center of the distribution were not thought to have similar locus of control characteristics to either internal or external subjects. Using this procedure 20 subjects were classified internal, 14 external and 31 had neither set of characteristics.

## RESULTS

Table 1 lists the means and standard deviations of all variables for elementary, middle school, and secondary preservice teachers. Both elementary and middle school teachers scored higher on the Teacher Performance Assessment Instrument (TPAI total) and each of the four broad teaching areas than did the secondary teachers. The secondary teachers scored higher on the Piaget task total than did middle school subjects who scored higher than

the elementary subjects. Locus of control scores varied little among the three groups.

A rule whereby 13 of 15 total points on the Piaget tasks indicates a fully formal (IIIb), level of functioning and from 10-13 points a transitional level (IIIa) and from 0-10 points a concrete level (IIa and IIb) was used to classify all subjects. Eighteen percent of elementary, 32% of middle school and 63% of secondary teachers were at the fully formal level. Seventy-seven percent of elementary, 65% of middle school and 37% of secondary were considered transitional. Only 5% and 3% of subjects in elementary and middle school, respectively, were rated as concrete. No secondary students were considered concrete.

A one way analysis of variance with teacher preparation level (elementary, middle school and secondary) as the independent variable and Piaget total task score as the dependent variable showed a significant difference ($F=4.56$, $p<.02$) among levels. A Newman-Keuls post hoc analysis showed both secondary ($p<.03$) and middle school subjects ($p<.10$) significantly higher than elementary subjects. It is important to note, however, that even the elementary subjects, on the average, were showing some formal abilities. Fully 11 of 20 elementary subjects responded formally on at least one Piaget task, indicating at least some formal abilities. Twenty-three of 27 middle school and 16 of 18 secondary subjects scored formal on at least one of the tasks.

Separate three way analyses of variance were performed with teacher preparation levels, Piaget total task score (formal and transitional) and locus of control score (internal, external and those who are neither internal or external) as independent variables and the four broad areas of

the TPAI and total TPAI score as the dependent variables. A main effect due to teacher preparation level was apparent for all dependent variables (T.P.M. $F=5.88$, $p<.01$; C. P. $F=4.72$, $p<.02$; I.S. $F=2.91$, $p<.07$; P.S. $F=3.99$, $p<.03$; TPAI total $F=6.08$, $p<.01$). No other main effects or interactions were significant. Newman-Keuls post hoc analyses was performed in an effort to ascertain which specific groups performed better than the others. For Teaching Plans and Materials both middle school ($p<.01$) and elementary students ($p<.05$) outperformed the secondary students. In the Classroom Procedures area the elementary subjects were significantly better than the secondary ($p<.10$). In Interpersonal Skills no significant post hoc differences were found. Both middle ($p<.05$) and elementary ($p<.01$) preservice teachers were significantly higher on the professional standards section. Overall, the middle ($p<.10$) and elementary ($p<.05$) teachers again outperformed secondary subjects (TPAI total).

The variables listed in Table 1 for all subjects were intercorrelated. Only one significant relationship was found, between scores on interpersonal skills competencies and the Pendulums Task ($r=.23$, $p<.07$). Since about two significant differences might be expected by chance alone, this one is not considered important.

## DISCUSSION

The lack of a significant relationship between any of the broad teaching performance categories and teacher cognitive development is interesting and not without importance. These results corroborate Miller's (1980) findings and indicate that at least for preservice teachers of the cognitive development levels reported here, the cognitive development is not an

important factor. However, one must be careful about generalizing this result to all populations. Most of the subjects in this study were functioning at a full formal or transitional level. Thus we can generalize only to similar populations. Miller's subjects came from the same university and the same programs. Other researchers have found far greater percentages of concrete operational teachers (e.g., Juraschek, 1974). Perhaps with this type of person, an important relationship might be found.

The increasing percentage of formal thinkers in middle school and especially secondary teacher training programs is not surprising. The heavy science coursework often times demands formal thinking abilities. This variable might well be an important self selection mechanism for determining teacher level. It is quite important to note that from 95% to 100% of each teaching level were at transitional or fully formal levels. This level is higher than has been reported in other studies and indicates that there are not great numbers of concrete operational teachers being produced. One possible reason for this difference is that other researchers tested education majors in their first years of college, while all subjects tested in this study were seniors.

The finding that both elementary and middle school subjects performed better in student teaching directly reflects their preparation emphasis. The secondary teacher training program emphasizes science content. Students take only 21 quarter hours of education, with minimal school experience, before student teaching. Elementary and to a lesser degree middle school teachers spend much of their last two years of college taking various education courses. They spend about ten weeks, half time, actually working in the field. Thus, the differences that were found were expected.

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Table 1

MEANS AND STANDARD DEVIATION OF ALL VARIABLES

| | Elementary N-20 | Middle School N=27 | Secondary N=18 |
|---|---|---|---|
| Total TPAI | $\bar{X}$ = 4.32 | 4.25 | 3.95 |
| | SD = .50 | .34 | .43 |
| Teaching Plans & Materials | $\bar{X}$ = 4.00 | 4.05 | 3.59 |
| | SD = .60 | .40 | .41 |
| Classroom Procedures | $\bar{X}$ = 4.36 | 4.24 | 4.02 |
| | SD = .49 | .39 | .49 |
| Interpersonal Skills | $\bar{X}$ = 4.50 | 4.50 | 4.33 |
| | SD = .50 | .45 | .52 |
| Professional Standards | $\bar{X}$ = 4.69 | 4.56 | 4.03 |
| | SD = .24 | .70 | .62 |
| Piaget Task Total | $\bar{X}$ = 12.15 | 13.04 | 13.50 |
| | SD = 1.69 | 1.19 | 1.38 |
| Displaced Volume | $\bar{X}$ = 2.55 | 2.37 | 2.83 |
| | SD = .60 | .56 | .38 |
| Balance Beam | $\bar{X}$ = 3.05 | 3.30 | 3.44 |
| | SD = .69 | .54 | .62 |
| Pendulum | $\bar{X}$ = 3.25 | 3.74 | 3.67 |
| | SD = .79 | .53 | .49 |
| Colorless Solutions | $\bar{X}$ = 3.30 | 3.63 | 3.61 |
| | SD = .73 | .63 | .61 |
| Locus of Control | $\bar{X}$ = 37.05 | 34.71 | 35.53 |
| | SD = 9.94 | 10.41 | 9.54 |
| SAT-Verbal | $\bar{X}$ =416.25 | 456.52 | 501.82 |
| | SD = 82.69 | 78.60 | 91.85 |
| SAT-Math | $\bar{X}$ =480.63 | 475.65 | 549.09 |
| | SD = 78.61 | 72.85 | 88.60 |
| NTE-Commons | $\bar{X}$ =584.94 | 590.36 | 670.33 |
| | SD = 64.15 | 72.06 | 87.38 |

1. Conservation of Displaced Volume (Karplus and Lavatelli, 1969) Two metal cylinders of equal volume but different mass are lowered into water. This task tested students' ability to discern whether the mass or volume of an object causes water to be displaced.

2. The Pendulum or Exclusion of Irrelevant Variables (Inhelder and Piaget, 1958) This tasks asks subjects to set up and conduct a fair experiment and to draw conclusions from that experiment. Several pendulums are compared to find out if the length of the pendulum, the weight of the bob, the force used to push the pendulum or the height from which it is dropped affect the period.

3. Equilibrium in the Balance (Inhelder and Piaget, 1958) This task tests subjects proportional reasoning ability. Weights are hung on a balance beam at specified distances from the fulcrum and the subject must balance the beam by hanging different weights at other distances.

4. Combinations of Colored and Colorless Chemical Bodies (Inhelder and Piaget, 1958) This task tests subjects abilities to systematically list all possible combinations of a set of elements. A certain combination of four colorless liquids when mixed with a fifth liquid will turn yellow. The subject must list and test all possible combinations.

Figure 1. Piaget task descriptions.

Competency VII: COMMUNICATES WITH LEARNERS.

Indicator 4. *Gives directions and explanations related to lesson content.*

Scale of Descriptors:

1. Fails to give any directions or explanations (either written or oral) when there is an obvious need to do so.

   OR

   Directions and explanations are difficult to understand and no attempt is made to remedy the confusion.

2. Directions or explanations are difficult to understand. Attempts to clarify confusion are largely ineffective.

3. Although most learners appear to understand, the teacher works with the entire group to clarify misunderstandings.

4. Only a few learners misunderstand. The teacher identifies specific learners who have difficulty with directions and explanations and helps them individually.

5. No evidence of learner confusion about directions or explanations is evident.

Comment: The intent of this indicator is to assess the ability of the teacher to effectively explain ideas and procedures related to lesson content. Observing learner reactions is necessary for an accurate rating.

Key points in descriptors:

1. Needed explanations are not given, or confusing directions are not clarified.

2. Attempts at clarification are ineffective.

3. Clarifies directions for the group when there is misunderstanding.

4. Individuals may be addressed within a group setting for brief clarifications, but lengthy clarifications should be handled individually.

5. Explanations are adequate for learners at the outset.

Figure 2. A sample indicator involved in assessing the competency "Communicates with Learners" from the Teacher Performance Assessment Instruments.

| Broad Area | Competency |
|---|---|
| Teaching Plans and Materials | Plans instruction to achieve selected objectives. |
| | Organizes instruction to take into account individual differences among learners. |
| | Obtains and uses information about the needs and progress of individual learners. |
| | Refers learners with special problems to specialists. |
| | Obtains and uses information about the effectiveness of instruction to revise it when necessary. |
| Classroom Procedures | Uses instructional techniques, methods, and media related to the objectives. |
| | Communicates with learners. |
| | Demonstrates a repertoire of teaching methods. |
| | Reinforces and encourages learner involvement in instruction. |
| | Demonstrates an understanding of the school subject being taught. |
| | Organizes time, space, materials and equipment for instruction. |
| Interpersonal Skills | Demonstrates enthusiasm for teaching and learning and the subject being taught. |
| | Helps learners develop positive self-concepts. |
| | Manages classroom interactions. |
| Professional Standards | Meets professional responsibilities. |
| | Engages in professional self-development. |

Figure 3. Broad areas and competencies within the Teacher Performance Assessment Instrument.